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PREFACE

Special section containing papers presented at the 13th IAEA Technical Meeting on Energetic Particles in Magnetic Confinement Systems (Beijing, China, 17–20 September 2013)

Guest Editor

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In magnetic fusion plasmas, a significant fraction of the kinetic pressure is contributed by superthermal charged particles produced by auxiliary heating (fast ions and electrons) and fusion reactions (a-particles). Since these energetic particles are often far away from thermal equilibrium due to their non-Maxwellian distribution and steep pressure gradients, the free energy can excite electromagnetic instabilities to intensity levels well above the thermal fluctuations. The resultant electromagnetic turbulence could induce large transport of energetic particles, which could reduce heating efficiency, degrade overall plasma confinement, and damage fusion devices. Therefore, understanding and predicting energetic particle confinement properties are critical to the success of burning plasma experiments such as ITER since the ignition relies on plasma self-heating by a-particles.

To promote international exchanges and collaborations on energetic particle physics, the biannual conference series under the auspices of the International Atomic Energy Agency (IAEA) were help in Kyiv (1989), Aspenas (1991), Trieste (1993), Princeton (1995), JET/Abingdon (1997), Naka (1999), Gothenburg (2001), San Diego (2003), Takayama (2005), Kloster Seeon (2007), Kyiv (2009), and Austin (2011). The papers in this special section were presented at the most recent meeting, the 13th IAEA Technical Meeting on Energetic Particles in Magnetic Confinement Systems, which was hosted by the Fusion Simulation Center, Peking University, Beijing, China (17-–20 September 2013). The program of the meeting consisted of 71 presentations, including 13 invited talks, 26 oral contributed talks, 30 posters, and 2 summary talks, which were selected by the International Advisory Committee (IAC). The IAC members include H. Berk, L.G. Eriksson, A. Fasoli, W. Heidbrink, Ya. Kolesnichenko, Ph. Lauber, Z. Lin, R. Nazikian, S. Pinches, S. Sharapov, K. Shinohara, K. Toi, G. Vlad, and X.T. Ding. The conference program, abstracts of all papers, and slides of oral presentations are available at the conference website: http://www.phy.pku.edu.cn/fsc/w18419.jsp

As a measure of the breadth in current research activities, a wide range of topics in energetic particle physics were covered in the meeting program, including dynamics of various Alfvén eigenmodes and energetic particle modes, energetic particle transport, energetic particle effects on magnetohydrodynamic (MHD) modes, runaway electrons, and diagnostics of energetic particles and neutrons. Energetic particle experiments were reported on tokamaks, stellarators, spherical tori, reversed field pinches, and linear devices. Most of the papers have direct comparisons between experimental data and simulation results, a very healthy trend in the research of energetic particle physics.

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As an indication for the depth in current research activities and possible future directions in energetic particle physics, some exciting progress reported at the meeting is highlighted here. The 3D fields of resonant magnetic perturbations (RMP) for controlling edge localized modes (ELM) are found to drive significant ripple loss of fast ions in DIII-D and ASDEX-U experiments. Similar loss is predicted for ITER RMP fields in the vacuum approximation. Fortunately, plasma response to RMP fields is found by the simulation to reduce the loss of fast ions and α-particles to a benign level. These results call for more accurate measurements and more reliable modeling of the plasma response to RMP fields in existing tokamak experiments and in future ITER experiments. Interesting progress on energetic particle transport by Alfvén eigenmodes was made in reduced 1D models based on the critical gradients model, in which energetic particle pressure gradients are relaxed to the local threshold of Alfvén eigenmode stability. Some experimental support for the critical gradient model was reported in DIII-D off-axis neutral beam injection (NBI) experiments, in which the fast-ion density relaxes to similar profiles for all injection angles. Further verification and validation of these reduced models by existing tokamak experiments and nonlinear simulations are needed.

Impressive progress in first-principles simulations of Alfvén eigenmodes and energetic particle transport was prominently featured at the meeting. Rigorous verification and validation have been successfully carried out for global gyrokinetic simulations of Alfvén eigenmodes with kinetic effects of thermal plasmas and non-perturbative contributions by energetic particles. The gyrokinetic turbulence simulation provides an indispensable new capability for studying the nonlinear physics of energetic particles and Alfvén eigenmodes by incorporating important physics of radial variations and toroidal mode coupling. For example, gyrokinetic simulations have found nonlinear oscillations of Alfvén eigenmode amplitude and frequency consistent with experimental observations. With better understanding of linear and nonlinear properties of Alfvén eigenmodes, a fruitful future direction is the self-consistent simulation of energetic particle transport, which requires long time simulations of nonlinear interactions between multiple Alfvén eigenmodes. A significant step in this direction has been taken by MHD-gyrokinetic hybrid simulations, which have demonstrated that fast ion profile is flattened by enhanced transport due to resonance overlaps in multiple interacting Alfvén eigenmodes with realistic amplitudes. A very interesting physics here is that the re-distribution of the energetic particle profile by an initially dominant Alfvén eigenmode leads to the excitation of other Alfvén eigenmodes. The broaden phase space volume for the extraction of free energy can then drive large fluctuation amplitudes and enhanced energetic particle transport. Some experimental evidences of such indirect interaction of multiple modes through energetic particles were observed in JT-60U and ASDEX-U experiments.

Thirteen papers presented at the meeting were reviewed to the usual high standard of *Nuclear Fusion* and published in this special section. On behalf of the IAC, I would like to thank all participants for their contributions to this conference and to thank *Nuclear Fusion* for publishing this special section. The next meeting of this series will be organized by Simon Pinches and will be held at the IAEA headquarters in Vienna, in the fall of 2015.